TESTING & RESULTS

EXPERIMENTS

The gripper is able to grasp and hold a range of objects of varying size and mass:

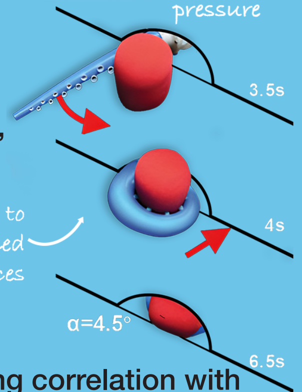
Object	Diameter	Mass
Mug	70mm	240g
Exercise Ball	750mm	500g
Test Tube	20mm	10g
Drinks Can	50mm	20g
Egg	35mm	50g
Smartphone	Planar	250g
Plastic Sheet	Planar	60g
Living Crab	N/A	400g

9.5° tapered actuator capable of gripping and holding 2.7kg at 250kPa pressure

The gripper is found to **wrap** planar objects into a shape for **transport** i.e. curling a magazine to pick it up.

The soft body and suction cups provide safe and secure grasping for delicate objects

The surrounding examples illustrate actuator **strength, delicacy, confined operation,** and **breadth** of application.



The tapered actuator is able to retrieve objects from confined spaces

RESULTS & CONCLUSIONS

- FEM-predictions show strong correlation with empirical data, allowing for **precise control** of actuator curvature.
- Experimental curvature analysis demonstrates that **the suckers do not alter the actuator's curvature** during pressurisation.
- Experimental analysis shows greater **flexibility, curvature, and adhesion for the tapered design** when compared with the non-tapered.
- **A broad range of objects** (size 5mm - 750mm, weight 10g - 2700g) could be grasped by the gripper, whilst still demonstrating strength, delicacy, adhesion, and flexibility.

FUTURE WORK

PROBLEM SOLVED?

The actuator succeeds in grasping a wide range of objects and operating in confined spaces. However, it is still a long way away from the robust and dexterous manipulation of the living Octopus!

CURRENT LIMITATIONS

Key challenges and improvements not addressed in this study include:

- Refining the design to allow object **manipulation** as well as simple grasping;
- Investigating the addition of **tactile feedback** for closed-loop control;
- Investigating the use of decoupled suction-cup and actuation control for more precise control;
- Optimising the **size and pattern of suckers** for different arm shapes.

FUTURE DIRECTIONS

Future gripper designs could incorporate more complex features, such as **three-dimensional bending, variable stiffness materials,** and more **realistic suckers.**

Additionally, mimicking the octopus's powerful suction requires further exploration of soft actuator materials such as **dielectric elastomers, shape memory polymers,** and **hydrogels.**

WANT TO LEARN MORE?

Scan here to watch videos and read the original paper on our website

Original reference paper:
Xie, Z., Domel, A.G., An, N., Green, C., Gong, Z., Wang, T., Knubben, E.M., Weaver, J.C., Bertoldi, K. and Wen, L., 2020. Octopus arm-inspired tapered soft actuators with suckers for improved grasping. Soft robotics, 7(5), pp.639-648.

THE GRIP OF THE OCTOPUS

A SOFT ROBOTIC END-EFFECTOR WITH A NOVEL DESIGN AND ACTIVE VACUUM ADHESION, INSPIRED BY THE OCTOPUS

Scan here for the augmented reality brochure

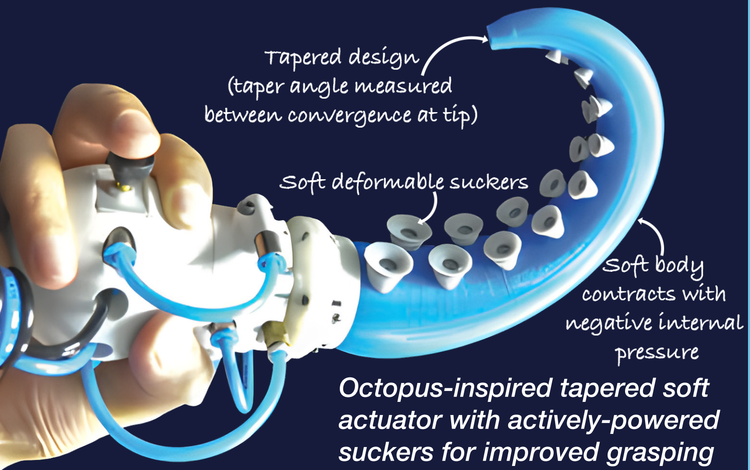
INTRODUCTION

Octopuses - the enigmatic creatures of the deep- possess **soft tapered tentacles** with remarkable **dexterity** and **flexibility** for precise and varied object manipulation. Here, we draw inspiration from the cephalopod's unique skills in **grasping and manipulating objects** of varying shapes, sizes, and textures to introduce a novel biomimetic gripper.

The Octopus tentacle utilises **bending** and **suction** cups to facilitate the capture of a broad array of prey and we use these concepts in our design.

PROBLEM STATEMENT

Conventional mechanical grippers require complex control strategies, often have a narrow range of objects they can grasp, and are unable to operate in confined spaces. We seek to address each of these issues through the investigation of a **soft biomimetic actuator with integrated suction**.



Octopus-inspired tapered soft actuator with actively-powered suckers for improved grasping

The **objective** of designing a soft robot actuator that mimics an octopus tentacle is to create a **flexible** and **strong movement mechanism**. The advantages of such a design includes improved **adaptability** in various environments, improved **handling** of delicate objects, and **potential** applications in medical and human-robot interaction applications.

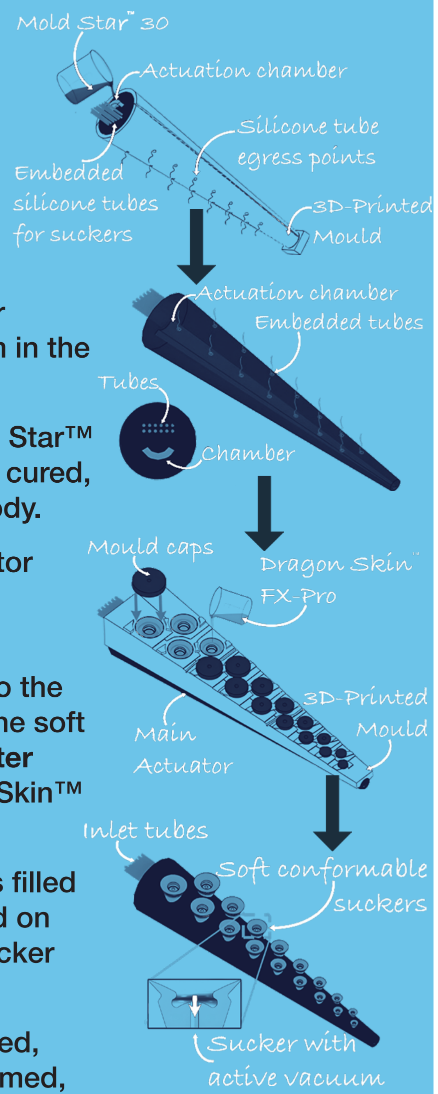
DESIGN & FABRICATION

DESIGN FEATURES

- A **Tapered actuator** with taper ranging from 3°-13.5°.
- A **pneumatic actuation chamber** running the length of the design to induce bending on inflation.
- 17 **soft suckers** integrated along the surface.
- Suckers connected to a **single vacuum line**, allowing **bending**.

HOW IT'S MADE

1. 3D-printed **moulds** are created (per taper angle), including holes for embedded **silicone tubes**, later used for creating the vacuum in the suckers.
2. An **elastomer** (Mold Star™ 30) is poured in and cured, forming the main body.
3. Once set, the actuator body is complete.
4. Another **3D-printed mould** is attached to the main body to cast the soft suckers using a **softer elastomer** (Dragon Skin™ FX-Pro).
5. The sucker mould is filled and **caps** are placed on top to create the sucker shape.
6. The mould is removed, excess silicone trimmed, and the actuator is **sealed** with silicone adhesive.

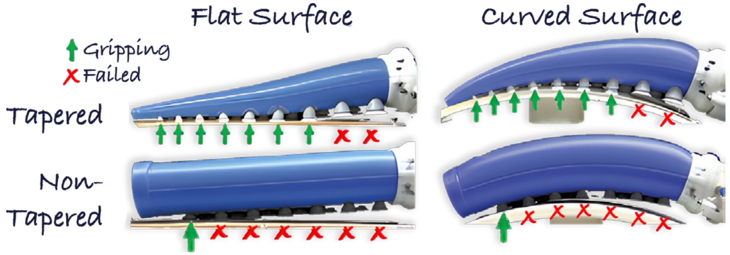


MECHANICAL PRINCIPLES

THE TAPERED DESIGN

The tapered design's **suction cups detach** from objects **gradually**, preventing slippage. For both curved and flat surfaces, the **non-tapered design fails instantaneously**, but the tapered version fails gradually.

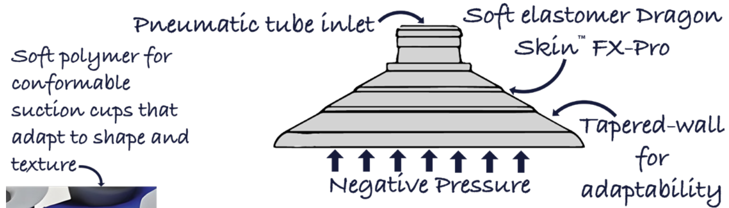
Scan here for more Augmented Reality



BENDING WITH SUCTION

The fabrication process integrates the pneumatic actuation for bending and vacuum-powered suckers through one activation mechanism, meaning the **suckers automatically suck when contracting.**

SUCTION CUPS



The conformable suckers **flex** to match object surfaces, providing improved **grip** on irregular shapes and textures.

The suckers' **tapered walls** augment flexibility by balancing forces and curvature **for precise control.**

The flexibility and tapered walls facilitate vacuum generation, creating a **robust seal.** This decreases the pressure and allows for controlled detachment.